PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2001-028300
(43)Date of publication of application : 30.01.2001

(51)Int.Cl. H05H 13/04
G21K 1/093

(21)Application number : 11-200355
(22)Date of filing : 14.07.1999

(71)Applicant : SHIN ETSU CHEM CO LTD
(72)Inventor : OHASHI TAKESHI

(54) INSERTION LIGHT SOURCE HAVING RADIATION RESISTANCE CHARACTERISTICS

(57)Abstract:
PROBLEM TO BE SOLVED: To enhance radiation and charged particle beam resistance characteristics and easily form required magnetic field distribution by installing a space between magnet lines, arranged so as to face magnet line formed by arranging rare earth permanent magnets whose magnetizing direction varies periodically, and arranging SmCo base sintered magnets at the ends of a magnet line formed by arranging NdFeB base sintered magnets.
SOLUTION: An insertion light source is formed by arranging SmCo-based magnets at the ends of magnet lines where electrode go in and out, and arranging NdFeB-based magnets in portions other than the ends, where magnetic field distribution become a periodical magnetic field. Since the NdFeB-based magnet easily causes demagnetization due to charged particle and the SmCo base magnet rarely causes demagnetization, the SmCo base magnet is used at the ends having high probability of irradiation of radiation or charged particle beams. Use of 2-17 type SmCo base magnet, having holding force mechanism by magnetic domain wall pinning and having both radiation characteristics several steps higher than 1-5 type SmCo-based magnet is preferable as the SmCo-based magnet.

LEGAL STATUS

[Date of request for examination] 16.10.2002
[Date of sending the examiner's decision of rejection]
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]
[Date of final disposal for application]
[Patent number]
[Date of registration]
[Number of appeal against examiner's decision of rejection]
[Date of requesting appeal against examiner's decision of rejection]
[Date of extinction of right]

(19)日本国特許庁（ＪＰ）

(12) 公開特許公報（Ａ）

(11)特許出願公開番号
特開2001－28300
（P2001－28300A）

(43)公開日 平成13年1月30日(2001.1.30)

(51)Int.Cl.⁷	識別記号	ＦＩ	テーマコード＊(参考)
Ｈ０５Ｈ 13/04		Ｈ０５Ｈ 13/04	Ｆ 2Ｇ０８５
Ｇ２１Ｋ 1/093		Ｇ２１Ｋ 1/093	Ｚ

審査請求 未請求 請求項の数４ ＯＬ （全 ６ 頁）

(21)出願番号 特願平11－200355

(22)出願日 平成11年7月14日(1999.7.14)

(71)出願人 000002060
信越化学工業株式会社
東京都千代田区大手町二丁目６番１号

(72)発明者 大橋 健
福井県武生市北府２丁目１番５号 信越化学工業株式会社磁性材料研究所内

(74)代理人 100062823
弁理士 山本 亮一 （外２名）

Ｆターム(参考) 2G085 AA03 AA13 BA11 BC11 BC20

(54)【発明の名称】 耐放射線特性を有する挿入光源

(57)【要約】

【課題】 耐放射線・粒子線特性に優れ、かつ所要の磁場分布を容易に形成することができる挿入光源を提供する。

【解決手段】 磁化方向が周期的に変化する希土類永久磁石を配列してなる磁石列を対向させて配置し、該磁石列間に空隙を設けた挿入光源において、ＮｄＦｅＢ系焼結磁石を配列してなる磁石列の端部にＳｍＣｏ系焼結磁石を配置する。

【特許請求の範囲】

【請求項１】　磁化方向が周期的に変化する希土類永久磁石を配列してなる磁石列を対向させて配置し、該磁石列間に空隙を設けた挿入光源において、ＮｄＦｅＢ系焼結磁石を配列してなる磁石列の端部にＳｍＣｏ系焼結磁石を配置することを特徴とする耐放射線特性を有する挿入光源。

【請求項２】　ＳｍＣｏ系焼結磁石を配置した磁石列の端部が、該磁石列の両端から、磁化方向変化の３周期分以下に相当する長さの部分である請求項１記載の挿入光源。

【請求項３】　真空装置内に設置される請求項１記載の挿入光源。

【請求項４】　磁石列間の空隙間隔を均一とし、かつ、該磁石列の端部に配置したＳｍＣｏ系焼結磁石の高さを、ＮｄＦｅＢ系焼結磁石よりも高くして、磁場分布が挿入光源の磁場仕様を満たすように最適化した請求項１記載の挿入光源。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、挿入光源、特に蓄積電流の大きな電子蓄積リングに用いると最適な挿入光源に関する。

【０００２】

【従来の技術】挿入光源は、電子加速器や電子蓄積リングの直線部分に挿入され、強力な放射光を発生させる装置として有用である。挿入光源には、図２に示すように、永久磁石１のみで構成されるハルバック型（ａ）と、永久磁石２及びポールピース３（鉄や鉄コバルト合金）で構成されるハイブリッド型（ｂ）がある。図２（ａ）、（ｂ）に示した挿入光源は、いずれも平面アンジュレータと呼ばれる一般的なタイプであり、周期的に磁化方向を変化させて配列した磁石列を対向させて配置し、該磁石列間の空隙に電子を走行させる（図１（ａ）参照）。挿入光源では、その磁石列間の空隙中にサインカーブ状の周期磁場が発生し（図１（ｂ）参照）、加速器中を回る高速電子は、該周期磁場の影響を受けて蛇行運動を行い、各蛇行点から放射光を生じる（図１（ｃ）参照、Ｈａｌｂａｃｈ，Ｎｕｃｌｅａｒ　Ｉｎｓｔｒｕｍｅｎｔｓ　ａｎｄ　Ｍｅｔｈｏｄ　１８７，（１９８１），１０９）。

【０００３】上記電子の蛇行運動は、その程度により、ウィグラーモードとアンジュレータモードに分けられる。ウィグラーモードでは各蛇行点から発生する放射光が重畳され、偏向電磁石からの放射光より１０倍～１０００倍高いパワーの白色放射光が得られる。これに対して、アンジュレータモードでは、各蛇行運動で発生する放射光が干渉し、基本波とその高次光では、ウィグラーモードの放射光の更に１０～１０００倍程度高いパワーの放射光が得られる。上記モードのいずれであるかは、Ｋ値（＝０．９３４$\lambda m B g$；λm＝周期長、Ｂｇ＝周期磁場のピーク値）と呼ばれるパラメーターにより分類される。Ｋ値が１前後あるいはそれ以下の場合はアンジュレータモードとなり、それ以外の値の場合はウィグラーモードとなる。

【０００４】挿入光源は、前記したように、大きく分けてハルバック型とハイブリッド型の２つの型があるが、どちらも、ほぼ同等の磁場強度や分布を示し、大きな違いはない。一般的にはハイブリッド型の方が、使用する磁石の量が少なくてすみ、また、挿入光源の開発の初期段階では、永久磁石の角度や特性のバラツキが大きかったため、ハルバック型よりハイブリッド型の方が、磁場強度を揃えやすかった。しかし、最近では、永久磁石のバラツキが小さく、特性が均一になっており、また、磁石の組み替え手法が導入されたため、どちらの型でもほぼ同等の磁場分布が得られる。ただし、磁石列間の空隙を変えた場合、ハルバック型における電子軌道のズレは、線形性がほぼ成立するため小さいが、ハイブリッド型は軟磁性ポールピースの使用により非線形性であるため、電子軌道のズレが生じやすい。結局、どちらの型の挿入光源を採用するかは、目的に応じて決定すればよく、特にどちらかが優れているというものではない。

【０００５】挿入光源には、通常、ＳｍＣｏ系焼結磁石（以下、ＳｍＣｏ系磁石という）よりもＮｄＦｅＢ系焼結磁石（以下、ＮｄＦｅＢ系磁石という）が使用される。その理由として、①挿入光源は室温以上に温度が上がる可能性は少ないので、室温で磁気特性の高いＮｄＦｅＢ系磁石を使用することにより、高い空隙磁場を得ることができる、②ＮｄＦｅＢ系磁石は着磁が容易で、磁気特性のバラツキが小さい、③挿入光源は磁場分布の精密調整が不可欠であり、磁場分布の乱れを生じさせている磁石セグメントに、磁石の位置調整、シミング磁石の付加、磁石表面での磁性体シミング等の操作を施して磁場調整する必要がある。そのため、磁石の抜き差しや挿入を頻繁に行うことになるが、その場合、ＮｄＦｅＢ系磁石はＳｍＣｏ系磁石に比べてワレカケが起こりにくいことが挙げられる。

【０００６】挿入光源の端部では、周囲の電磁気的環境や鉄材の配置などから、磁場の洩れや乱れが起こりやすい。また、挿入光源の空隙間に入れる真空容器は、その直線部が絞り込まれているため真空のコンダクタンスに違いが生じ、その結果、真空度が上がりにくく、残留ガスが多くなる可能性も高い。これらの原因により、電子の一部が散乱して、真空容器や挿入光源に衝突したり、散乱した電子が発生する電磁波（放射光）やその照射で発生した２次電子などに挿入光源の磁石が晒される場合がある。そして、このような種々の要因が重畳することにより、挿入光源の磁石が減磁してしまう。この減磁は熱によるものではなく、放射線照射に起因する問題である。

【０００７】さらに、最近、真空装置内に挿入光源を設置する真空封止型挿入光源が開発され、実用化が進んでいる。しかし、真空封止型挿入光源では、加速電子や２次電子が磁石に衝突する確率も増加し、また、磁石に照射される放射光（硬Ｘ線を含む）の強度も増加する。その上、放射光や電子により、局所的に磁石が加熱されることも考えられる。したがって、真空封止型挿入光源では、磁石の減磁が深刻な問題となっていた。

【０００８】

【発明が解決しようとする課題】そこで、本発明は、耐放射線・粒子線特性に優れ、かつ所要の磁場分布を容易に形成することができる挿入光源の提供を目的とする。

【０００９】

【課題を解決するための手段】本発明は、磁化方向が周期的に変化する希土類永久磁石を配列してなる磁石列を対向させて配置し、該磁石列間に空隙を設けた挿入光源において、ＮｄＦｅＢ系焼結磁石を配列してなる磁石列の端部にＳｍＣｏ系焼結磁石を配置することを特徴とする耐放射線特性を有する挿入光源である。

【００１０】

【発明の実施の形態】本発明の挿入光源は、電子が出入りする磁石列の端部にＳｍＣｏ系磁石を配置し、磁場分布が周期磁場状態となる端部以外の部分に、ＮｄＦｅＢ系磁石を配置したものである。本発明において、磁石列の端部にＳｍＣｏ系磁石を採用した理由は、放射線や粒子線の照射により希土類磁石が減磁する機構は、未だ不明であるが、数少ない実験結果から、放射線等による減磁は、熱による減磁と似た挙動を示し、また、ＮｄＦｅＢ系磁石の方が粒子線による減磁を起こしやすく、ＳｍＣｏ系磁石は比較的減磁しにくいことから、放射線や粒子線が照射される確率の高い端部には、ＳｍＣｏ系磁石を使用することにしたものである。

【００１１】使用するＳｍＣｏ系磁石は、特には２－１７型ＳｍＣｏ系磁石が望ましい。磁壁ピンニングによる保磁力機構を持つ２－１７型ＳｍＣｏ系磁石は、核発生成長型の保磁力機構を持つ１－５型ＳｍＣｏ系磁石に比較しても、数段優れた耐放射線性を有するからである。なお、図３にＳｍＣｏ系磁石Ｒ２６Ｈ（信越化学社製、商品名）とＮｄＦｅＢ系磁石Ｎ３３Ｈ（信越化学社製、商品名）に、１７ＭｅＶの電子を照射した時の減磁の様子と、表１に保磁力１８ｋＯｅの上記ＮｄＦｅＢ磁石（試料Ｎｏ．１，４）と上記ＳｍＣｏ系磁石（試料Ｎｏ．２，３）に電子線照射（入射電子エネルギー１７ＭｅＶ（推定）、平均電流２００ｎＡ／ｃｍ^2、パルス幅１．５μｓパルス列６０ｐｐｓ）した時の減磁の数値を示した。

【００１２】

【表１】

試料No.	累積照射量 [C/cm^2]	照射後の磁束減磁量 [％]
1	7．2×10^{-4}	97．9
2	7．2×10^{-4}	98．3
3	2．1×10^{-3}	91．5
4	2．1×10^{-3}	90．6

【００１３】ＳｍＣｏ系磁石を配置する端部の部分は、磁石列の両端から、磁化方向変化の３周期分以下に相当する長さの部分であればよく、磁石の使用量を最小限にとどめる場合は、１．５周期分でよい。この部分が放射線等の照射により、大きく減磁する可能性の高い部分だからである。磁石列の端部の磁場は、電子軌道をキックさせ、基準となる中心軸からずらせる働きをする。端部磁石の調整により電子軌道を整えることも可能であるが、ステアリング電磁石のような軌道調整用の手段を設ける場合が多い。このため端部磁石の磁場分布調整は粗く行うだけでよい。したがって、本発明において、ＳｍＣｏ系磁石が有する欠点であるワレカケについては、ほとんど問題とならない。

【００１４】本発明では、端部以外の部分には、ＮｄＦｅＢ系磁石を用いる。前記したように、ＮｄＦｅＢ系磁石は、機械特性が良好で、磁気特性のバラツキが小さく、室温磁気特性が高いからである。サイン波磁場分布が実現できている領域では、電子軌道の乱れが少なく、放射線や粒子線による磁石照射が少なくなるため、ＮｄＦｅＢ系磁石を使用しても減磁はほとんど生じない。挿入光源を真空容器中に収納する真空封止型挿入光源では、放射線照射等の影響がより大きくなるが、本発明の磁石構成で作製された挿入光源は、減磁が抑えられ、その影響は無視できる。

【００１５】磁石列の端部に配置するＳｍＣｏ系磁石は、一般に（ＢＨ）ｍａｘが３０ＭＧＯｅ程度であり、端部以外に配置するＮｄＦｅＢ系磁石は、（ＢＨ）ｍａｘが４０～５０ＭＧＯｅである。そのため、ＳｍＣｏ系磁石とＮｄＦｅＢ系磁石を同じ寸法にすると、端部の磁場積分値が不足する。端部と端部以外の磁場積分値を同一にする方法として、ＳｍＣｏ系磁石の幅を広くすることも考えられるが、放射線光に余分な高次光をもたらす危険性がある。そこで、ＳｍＣｏ系磁石の高さを、ＮｄＦｅＢ系磁石より高くして、磁場分布が挿入光源の磁場仕様を満たすように最適化することが望ましい。この場合、対向する磁石列間の空隙間隔を均一とし、両磁石の高さの差は、空隙に面する側とは反対側の架橋面側で吸収することが望ましい。これによりＳｍＣｏ系磁石を端部に使用しても、挿入光源の全体磁場分布は、単一の磁石材料を使用した場合と同じものが得られる。

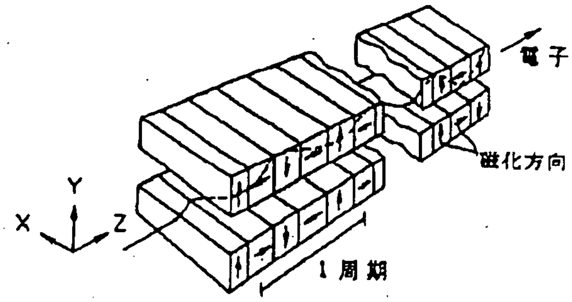
【００１６】

【実施例】次に、本発明について、実施例を示すが、本発明はこれに限定されるものではない。

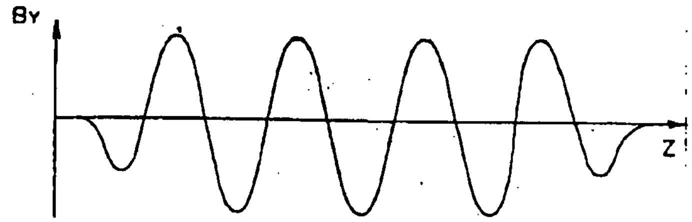
（実施例）周期長４０ｍｍ、３０周期のハルバック型挿

【図1】

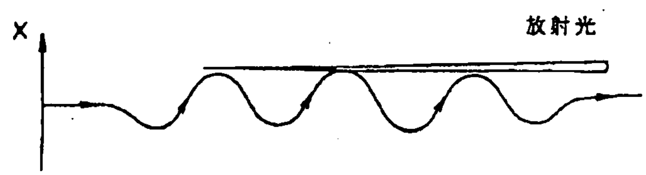
(a)



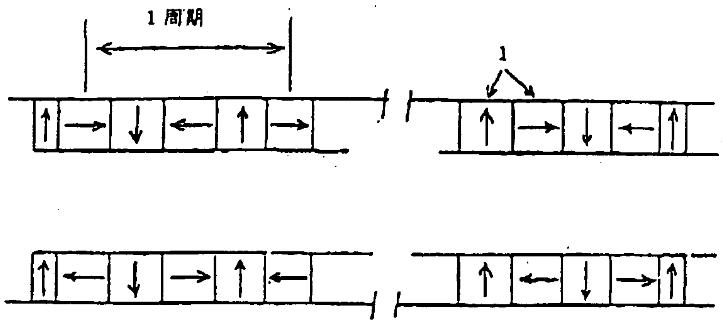
(b)



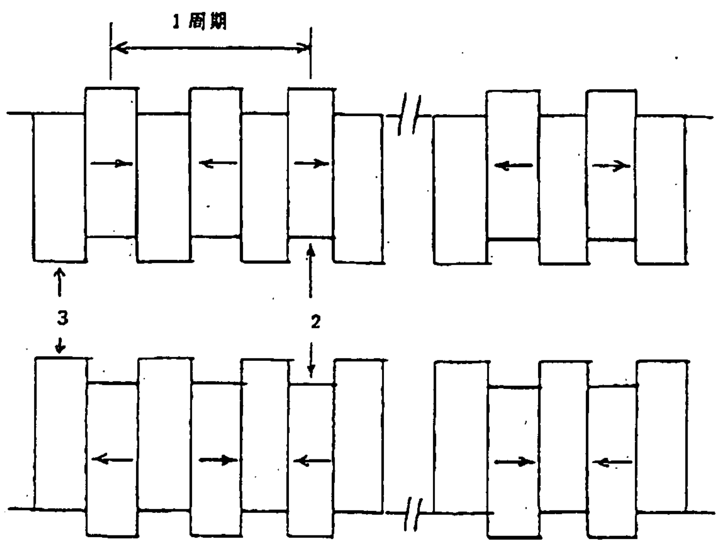
(c)



【図2】



(a)



(b)

Bibliography

---

(19) [Publication country] Japan Patent Office (JP)
(12) [Kind of official gazette] Open patent official report (A)
(11) [Publication No.] JP, 2001-28300, A (P2001-28300A)
(43) [Date of Publication] January 30, Heisei 13 (2001. 1.30)
(54) [Title of the Invention] The insertion light source which has a radiation-proof property
(51) [The 7th edition of International Patent Classification]
H05H 13/04
G21K 1/093
[FI]
H05H 13/04 F
G21K 1/093 Z
[Request for Examination] Un-asking.
[The number of claims] 4
[Mode of Application] OL
[Number of Pages] 6
(21) [Application number] Japanese Patent Application No. 11-200355
(22) [Filing date] July 14, Heisei 11 (1999. 7.14)
(71) [Applicant]
[Identification Number] 000002060
[Name] Shin-Etsu Chemical Co., Ltd.
[Address] 2-6-1, Otemachi, Chiyoda-ku, Tokyo
(72) [Inventor(s)]
[Name] Ohashi **
[Address] 2-1-5, Kitago, Takefu-shi, Fukui-ken Inside of the Shin-Etsu Chemical Co., Ltd. magnetic material lab
(74) [Attorney]
[Identification Number] 100062823
[Patent Attorney]

[Name] Yamamoto Ryoichi (outside binary name)
[Theme code (reference)]
2G085
[F term (reference)]
2G085 AA03 AA13 BA11 BC11 BC20

Epitome

---

(57) [Abstract]
[Technical problem] The insertion light source which is excellent in a radiation-proof and a corpuscular ray property, and can form necessary magnetic field distribution easily is offered.
[Means for Solution] The magnetization direction makes the magnet train which comes to arrange the rare earth permanent magnet which changes periodically counter, arranges, and arranges a SmCo system sintered magnet at the edge of the magnet train which comes to arrange a NdFeB system sintered magnet in the insertion light source which prepared the opening between these magnet trains.

[Translation done.]

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.
1.This document has been translated by computer. So the translation may not reflect the original precisely.

2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] The insertion light source which has the radiation-proof property characterized by for the magnetization direction making the magnet train which comes to arrange the rare earth permanent magnet which changes periodically counter, arranging, and arranging a SmCo system sintered magnet at the edge of the magnet train which comes to arrange a NdFeB system sintered magnet in the insertion light source which prepared the opening between these magnet trains.
[Claim 2] The insertion light source according to claim 1 whose edge of the magnet train which has arranged the SmCo system sintered magnet is the part of the die length which is equivalent to below by three periods of the both ends of this magnet train to the magnetization direction change.
[Claim 3] The insertion light source according to claim 1 installed in vacuum devices.
[Claim 4] The insertion light source according to claim 1 optimized so that the height of the SmCo system sintered magnet which made opening spacing between magnet trains homogeneity, and has been arranged at the edge of this magnet train might be made higher than a NdFeB system sintered magnet and magnetic field distribution might fulfill the magnetic field specification of the insertion light source.

[Translation done.]

2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] When this invention is used for the big electronic storage rings of the insertion light source, especially an are recording current, it relates to the optimal insertion light source.
[0002]
[Description of the Prior Art] The insertion light source is useful as equipment which is inserted in the straight-line parts of an electron accelerator or electronic storage rings, and is made to generate powerful synchrotron orbital radiation. As shown in drawing 2 , there are a hull back mold (a) which consists of only permanent magnets 1, and a hybrid mold (b) which consists of a permanent magnet 2 and pole piece 3 (iron and iron cobalt alloy) in the insertion light source. Each insertion light source shown in drawing 2 (a) and (b) is a common type called flat-surface undulater, makes the magnet train which the magnetization direction was changed and arranged it periodically counter, and is arranged, and the opening between these magnet trains is run an electron (refer to drawing 1 (a)). In the insertion light source, the high-speed electron which the periodic magnetic field of the letter of a sign curve occurs (refer to drawing 1 (b)), and turns around the inside of an accelerator all over the opening between the magnet train performs meandering movement in response to the effect of this periodic magnetic field, and produces synchrotron orbital radiation from each point moving in a zigzag direction (refer to drawing 1 (c), Halbach, Nuclear Instruments and Method 187, (1981), 109).
[0003] Meandering movement of the above-mentioned electron is boiled to that extent, and is divided more into wiggler mode and undulater mode. In wiggler mode, it is superimposed on the synchrotron orbital radiation generated from each point moving in a zigzag direction, and the white synchrotron orbital radiation of 1000 times [10 times to] as high power as the synchrotron orbital radiation from a deviation electromagnet is obtained. On the other hand, in undulater mode, the synchrotron orbital radiation generated in each meandering movement interferes, and the synchrotron orbital radiation of the power of the synchrotron orbital radiation in wiggler mode high about further 10 to 1000 times is obtained with a fundamental wave and its high order light. It is classified according to the parameter called K value (peak value of =0.934lambda mBg;lambda m= cycle length and Bg= period magnetic field) any in the above-mentioned mode they are. When K value is less than [1 order or it], it becomes undulater mode, and in the case of

the other value, it becomes wiggler mode.

[0004] Although the insertion light source is roughly divided and has two molds, a hull back mold and a hybrid mold, as described above, almost equivalent magnetic field strength and distribution are shown, and a big difference does not have both. Generally there were few amounts of the magnet which the direction of a hybrid mold uses, and it ended, and in the initial stage of development of the insertion light source, since the include angle of a permanent magnet and the variation of a property were large, a hybrid mold tended to arrange magnetic field strength from a hull back mold. However, recently, since technique for the variation in a permanent magnet to be small, and for the property have become homogeneity, and rearrange a magnet was introduced, almost equivalent magnetic field distribution is acquired with both of the molds. However, when the opening between magnet trains is changed, since linearity is materialized mostly, gap of the electron orbit in a hull back mold is small, but by use of soft magnetism pole piece, since a hybrid mold is nonlinearity, gap of an electron orbit tends to produce it. After all, it is not excellent [especially either] of which mold the insertion light source is adopted that what is necessary is just to determine according to the purpose.

[0005] A NdFeB system sintered magnet (henceforth a NdFeB system magnet) is usually used for the insertion light source rather than a SmCo system sintered magnet (henceforth a SmCo system magnet). Since there is little possibility that temperature will go up ** insertion light source beyond a room temperature, as the reason **NdFeB system magnet which can obtain a high opening magnetic field by using the high NdFeB system magnet of magnetic properties at a room temperature is easy to magnetize. ** insertion light source with the small variation in magnetic properties is indispensable, and precision adjustment of magnetic field distribution needs to operate magnetic justification, addition of a shimming magnet, magnetic-substance shimming on the front face of a magnet, etc. to the magnet segment which is producing turbulence of magnetic field distribution, and needs to carry out magnetic field adjustment of it. Therefore, although extraction and insertion and insertion of a magnet will be performed frequently, as for a NdFeB system magnet, it is mentioned in that case that WAREKAKE cannot happen easily compared with a SmCo system magnet.

[0006] At the edge of the insertion light source, the leak and turbulence of a magnetic field tend to arise from the surrounding electromagnetic-like environment, arrangement of iron material, etc. Moreover, possibility of the vacuum housing put in between the openings

of the insertion light source that a difference will arise in vacuous conductance since the bay is narrowed down, consequently will be hard to go up a degree of vacuum, and residual gas will increase is also high. According to these causes, electronic [some] is scattered about, it may collide with a vacuum housing or the insertion light source, or the magnet of the insertion light source may be exposed to the secondary electron generated in the electromagnetic wave (synchrotron orbital radiation) which the scattered electrons generate, or its exposure. And when such various factors are overlapped, the magnet of the insertion light source will demagnetize. This demagnetization is a problem which is not based on heat and originates in radiation irradiation.

[0007] Furthermore, the vacuum lock mold insertion light source which installs the insertion light source in vacuum devices is developed, and utilization is progressing recently. However, in the vacuum lock mold insertion light source, the reinforcement of the synchrotron orbital radiation (hard X ray is included) to which the probability for an acceleration electron and a secondary electron to collide with a magnet also increases and which is irradiated by the magnet also increases. Moreover, it is also considered with synchrotron orbital radiation or an electron that a magnet is heated locally. Therefore, in the vacuum lock mold insertion light source, magnetic demagnetization had become a serious problem.

[0008]

[Problem(s) to be Solved by the Invention] Then, this invention aims at offer of the insertion light source which is excellent in a radiation-proof and a corpuscular ray property, and can form necessary magnetic field distribution easily.

[0009]

[Means for Solving the Problem] This invention is the insertion light source which has the radiation-proof property characterized by for the magnetization direction making the magnet train which comes to arrange the rare earth permanent magnet which changes periodically counter, arranging, and arranging a SmCo system sintered magnet at the edge of the magnet train which comes to arrange a NdFeB system sintered magnet in the insertion light source which prepared the opening between these magnet trains.

[0010]

[Embodiment of the Invention] The insertion light source of this invention arranges a SmCo system magnet at the edge of a magnet train which an electron frequents, and arranges a NdFeB system magnet into parts other than the edge where magnetic field distribution will be in a

periodic magnetic field condition. Although the device in which a rare earth magnet demagnetizes the reason for having adopted the SmCo system magnet as the edge of a magnet train by the exposure of a radiation or a corpuscular ray in this invention is still unknown From a few experimental results, the demagnetization by a radiation etc. Since the behavior similar to demagnetization by heat is shown and neither a lifting nor the SmCo system magnet which becomes empty can demagnetize demagnetization according [the direction of a NdFeB system magnet] to a corpuscular ray comparatively easily, a SmCo system magnet will be used for the high edge of the probability for a radiation and a corpuscular ray to be irradiated.

[0011] Especially the SmCo system magnet to be used has a desirable 2-17 mold SmCo system magnet. Even if it compares the 2-17 mold SmCo system magnet with the coercive force device by magnetic domain wall pinning with a 1-5 mold SmCo system magnet with the coercive force device of the generation length mold from a nucleus, it is because it has the radiation resistance which was excellent several steps. In addition, the situation of the demagnetization when irradiating [at drawing 3] the electron of 17MeV SmCo system magnet R26H (the Shin-etsu chemistry company make, trade name) and NdFeB system magnet N33H (the Shin-etsu chemistry company make, trade name), Table 1 -- the above-mentioned NdFeB magnet (1 sample No. 4) of coercive force 18kOe, and the above-mentioned SmCo system magnet (2 sample No. 3) -- electron beam irradiation (incidence electronic energy -- 17 MeV (presumption)) The numeric value of the demagnetization when carrying out average current 200 nA/cm2 and 1.5 microsecond pulse train 60pps of pulse width was shown.

[0012]

[Table 1]

試料No.	累積照射量 [C/cm^2]	照射後の磁束減磁量 [%]
1	7.2×10^{-4}	97.9
2	7.2×10^{-4}	98.3
3	2.1×10^{-3}	91.5
4	2.1×10^{-3}	90.6

[0013] The part of the edge which arranges a SmCo system magnet is good with 1.5 periods, when minimizing the amount of magnetic [used] from the both ends of a magnet train that what is necessary is just the part of the die length which is equivalent to below by three periods of the magnetization direction change. It is because this part is a high part of possibility of demagnetizing greatly by the exposure of a radiation

etc. The magnetic field of the edge of a magnet train makes an electron orbit kick, and serves to be able to shift from the medial axis used as criteria. Although it is also possible to prepare an electron orbit by adjustment of an edge magnet, a means for orbital adjustment like a steering electromagnet is established in many cases. For this reason, what is necessary is just to perform magnetic field distribution adjustment of an edge magnet coarsely. Therefore, in this invention, it hardly becomes a problem about WAREKAKE which is the fault which a SmCo system magnet has.

[0014] A NdFeB system magnet is used for parts other than an edge in this invention. It is because a NdFeB system magnet has a good mechanical characteristic, its variation in magnetic properties is small and room temperature magnetic properties are high, as described above. In the field which has realized sine wave magnetic field distribution, there is little turbulence of an electron orbit, and since the magnet exposure by the radiation or the corpuscular ray decreases, even if it uses a NdFeB system magnet, demagnetization is hardly produced. Although the effect of radiation irradiation etc. becomes larger in the vacuum lock mold insertion light source which contains the insertion light source in a vacuum housing, as for the insertion light source produced with the magnet configuration of this invention, demagnetization is suppressed, and the effect can be disregarded.

[0015] (BH) max of the NdFeB system magnet with which the SmCo system magnet arranged at the edge of a magnet train is 30MGOe extent, and (BH) max generally arranges it in addition to an edge is 40 - 50MGOe. Therefore, if a SmCo system magnet and a NdFeB system magnet are made into the same dimension, the magnetic field integral values of an edge run short. Although making large width of face of a SmCo system magnet is also considered as an approach of making the same magnetic field integral values other than an edge and an edge, there is a danger of bringing an excessive high order light to radiation light. Then, it is desirable to make the height of a SmCo system magnet higher than a NdFeB system magnet, and to optimize so that magnetic field distribution may fulfill the magnetic field specification of the insertion light source. In this case, opening spacing between the magnet trains which counter is made into homogeneity, and, as for the side which faces an opening, it is [the difference of the height of both magnets] desirable to absorb by the bridge formation side side of the opposite side. Even if this uses a SmCo system magnet for an edge, the same thing as the case where the magnetic field distribution by the whole insertion light source uses a single magnet ingredient is obtained.

[0016]
[Example] Next, although an example is shown about this invention, this invention is not limited to this.
(Example) (BH) max used the hull back mold insertion light source of 40mm of cycle length, and 30 periods, (BH) max used the 2-17 mold SmCo system magnet segment (the Shin-etsu chemistry company make; R30) with a thickness [of 10mm] x width-of-face [of 80mm] x height [of 28MGOe(s)] of 50mm with the NdFeB system magnet segment (the Shin-etsu chemistry company make; N42) with a thickness [of 10mm] x width-of-face [of 80mm] x height [of 42MGOe(s)] of 30mm, and it produced. Only the SmCo system magnet segment of an endmost part made thickness one half. The SmCo system magnet has arranged only the die length which is equivalent to two periods each from both ends. And it finished setting up each magnet segment, spacing of the opening between magnet trains was set to 25mm, and magnetic field distribution was adjusted. Magnetic field distribution was adjusted by changing the location of a magnet train in the direction of an opening. 85 G-cm and the double integral value of 1 multiple-integral value after magnetic field distribution adjustment were 1000 G-cm2, and most orbital adjustments with a steering coil were level without the need. The above-mentioned hull back mold insertion light source was used for 38MeV electronic linac, and 20MeV electrons were accelerated. Other conditions were made into 1.5 microseconds of pulse width, pulse incidence 60pps, and pulse peak current value 23 mA/cm2, and performed incidence continuously for 1 hour. Then, when the insertion light source was removed from the above-mentioned linac and magnetic field distribution (a magnetic-flux integral value and homonymy) was measured, an exposure front and change were not in the range of the accuracy of measurement. This showed that the insertion light source of this invention had the resistance over a radiation and a corpuscular ray.
[0017]
[Effect of the Invention] The insertion light source of this invention is excellent in a radiation-proof and a corpuscular ray property, and can form necessary magnetic field distribution easily, and it can be used for it, without causing demagnetization, even if it uses for linac with a big current value.

[Translation done.]

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.

2. **** shows the word which can not be translated.

3. In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] (a) is [the periodic magnetic field of (a) and (c of the outline perspective view of the insertion light source and (b))] the electron orbits of (a).

[Drawing 2] It is the schematic diagram of basic magnet arrangement of flat-surface undulater, and (a) is a hull back mold and (b) is a hybrid mold.

[Drawing 3] It is drawing showing the demagnetization when irradiating the electron of 17MeV(s) to a SmCo system magnet and a NdFeB system magnet.

[Description of Notations]

1 Two Permanent magnet

3 Pole Piece

[Translation done.]

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

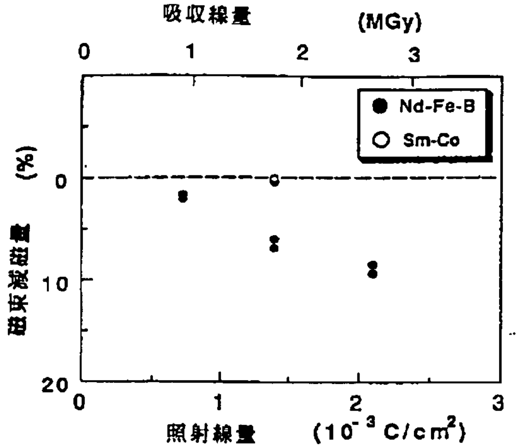
1. This document has been translated by computer. So the translation may not reflect the original precisely.

2. **** shows the word which can not be translated.

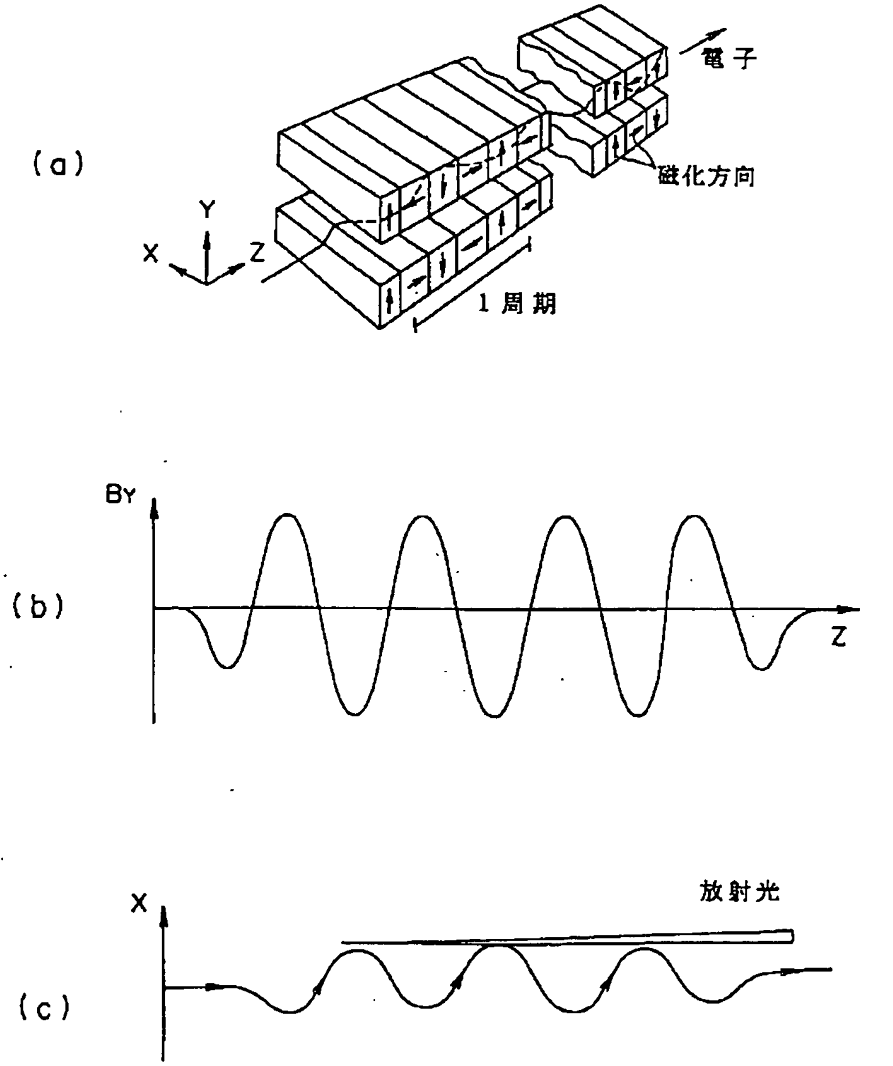
3. In the drawings, any words are not translated.

DRAWINGS

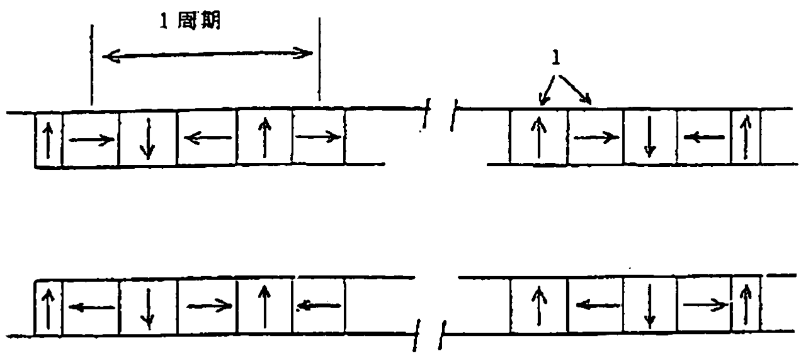
[Drawing 3]



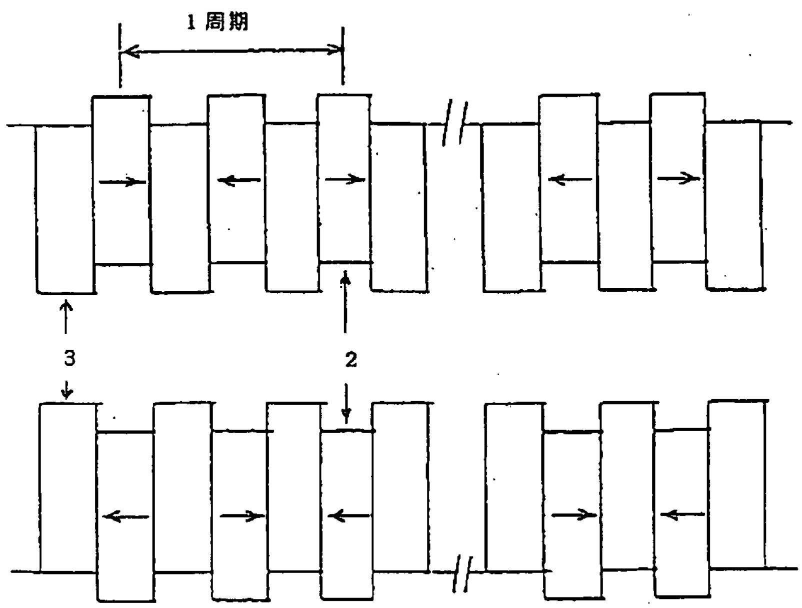
[Drawing 1]



[Drawing 2]



(a)



(b)

[Translation done.]